

The DZERO Rack Monitor Module

Al Frank, Rich Mahler, and Mike Shea

1.0 INTRODUCTION

A general purpose monitoring module has been designed for acquiring hardware monitoring data from the D0 facility. This module will be used to measure parameters such as temperatures and power supply voltages on the platform and in the movable counting house.

The design goals were to implement a small module with enough capacity to satisfy the monitoring requirements of a single relay rack and to connect of these modules to a control system VMEbus crate over a single cable. Because of noise considerations, no processors or clocks are allowed on the D0 detector platform. Therefore, the monitor chassis must be a "dumb" device.

2.0 GENERAL DESCRIPTION

The monitor chassis includes both analog and digital, input and output. The majority of the D0 monitoring requirements are for analog inputs used to interface temperature sensors, power supply voltage and current monitors. Specifications for the module are given in Table 1. Figure 1 is a block diagram of the module.

Physically, the monitor module is housed in a small self-powered rack mounted chassis. All I/O connections are made using "D" type connectors at the back panel of the chassis. Sixteen differential A/D inputs are available on each of four 37-pin connectors. Four words of digital data are also interfaced to each of four 37-pin D connector. The 16 bits of data from a single connector are arranged to provide alternate signal and ground conductors in an attached ribbon cable. A one microsecond positive strobe signal is included in each digital I/O connector to indicate when data is read or stored by the control system. Multiple word transfers to and from the digital I/O connectors are supported, and the word count for each word is given on five pins of the digital connectors. The counter can be disabled by front panel switch. The data direction for each of the four words of digital I/O is switch selectable by a segment of a front panel piano dip switch. Two 9-pin D connectors are used for eight D/A output signals. On the Rack

Monitor chassis, all input-output connectors are socket type.

The monitor chassis is connected to the control system using the MIL-STD-1553B multiplexed data bus standard. This protocol allows several chassis to be daisy-chained together using a single shielded twisted pair cable to connect to a MIL-1553B controller that is located in a VMEbus control crate.

3.0 PHYSICAL CHARACTERISTICS

The Rack Monitor is contained in a 1 U (1.75") x 19" rack mountable chassis. All output signals are available on the rear panel and status indicators are located on the front panel. Several switches and an AC line fuse are also accessible from the front of the module.

3.1 The Front Panel

Figure 2a is a diagram of the front panel of the Monitor Module showing the indicator LEDs and the address/mode-control switches. In addition to the power supply indicator LEDs (for the +5, +9, +15 and -15V supplies), LEDs are included to show "*Module Select*", "*Module Reset*" and "*Oscillator Power*"

Module Reset is driven by a retriggerable one-shot that will cause a reset to occur if the module has not been addressed for about 10

Analog:		
Input:	-No. of Channels	64 Differential
	-Input Range	-10 to +10 volts
	-Input Resolution	12 Bits
	-Overvoltage Protection	35V to gnd, Max.
	-Input Impedance	>10 Megohms
	-Source Impedance of Inputs	2 Kohms
Output:	-No. of Channels	8
	-Output Voltage Range	-10 to +10 volts
	-Output Current	5mA
	-Resolution	12 Bits
Digital I/O[†]:		
	-No. of bits	64 (4-16 bit words)
	-Input Levels	TTL
	-Strobe Width [§]	1 μs nom.
Interface to Control Computer:	MIL-STD-1553	
Power Input:	90-130VAC 30 Watts Typ.	
<div>Notes: § Strobes indicate when data is read or written. Output data is valid on the trailing edge of the one microsecond positive strobe (high to low transition).</div> <div>† Data direction of each word is set by a front panel switch.</div>		

Table 1. Rack Monitor Specifications

seconds. This signal only resets the MIL-1553B interface circuit and not the latched D/A or digital output data.

Piano-dip switches are accessible through the front panel. An *open* (switch in the up position) corresponds to a logic "1". Five bits are used to set the RT address of the module. Each module on a given MIL-1553B bus must have a unique address. Four switch sections control the data direction of the digital I/O data, and other switches inhibit the digital I/O counter and select between the continuous and pulsed oscillator power modes.

3.2 The Rear Panel

All I/O connections to the rack monitor chassis are made through 37-contact socket type "D" connectors on the rear panel. As shown in Figure 2b, the chassis has an upper and a lower group of connectors that are mounted to the circuit board in the chassis.

Pinouts of all analog and digital I/O interface connectors are given in Figure 3. These figures include the conductor number of each signal in an attached ribbon cable as well as the pin number of the D-type connector on the chassis.

4.0 MIL-STD-1553B

MIL-1553B is a definition of a 1 MHz serial multiplexed data bus that operates over a single shielded twisted pair cable. Because it is a standard, the necessary protocol interface circuits are commercially available as integrated circuit controllers.

Data transfers over the MIL-1553B bus are command/response type of communication. A command is sent out by a VMEbus controller to the Remote Terminal (RT) and a status word response is returned by the RT. Data immediately follows the command word or the status word depending on the direction of the data transfer. The data acquisition chassis described here functions as a MIL-1553 RT. Data within the RT are accessed by specifying the RT address, the subaddress within the selected RT, the number of words and the direction of the data transfer. All of these parameters are included in the sixteen bit command word sent out by the controller to initiate the transfer. The MIL-1553B LSI protocol chip searches for common error types such as timing errors, invalid commands, parity errors, lack of response, response from the wrong RT address, and hardware signaling errors.

The monitor chassis is designed to be a direct coupled Remote Terminal device that operates according to the MIL-STD-1553B specification. The direct coupled design causes multiple modules to be connected to the controller as a daisy chain, using the appropriate single shielded twisted pair cable. The transformer coupling dictated by the MIL-1553B specification eliminates ground currents between multiple RTs. The two twinax connectors needed for the daisy chain connection are shown in Figure 2b.

Use of the MIL-STD -1553B for these modules has many advantages:

- Several modules (between 1 and 30) may be driven from a single controller module in a VMEbus crate.
- Each MIL-1553B bus requires only a single cable.
- Each Remote Terminal is isolated from the bus by the transformer-coupled

connection required by the specification.

- The MIL-1553B bus is inactive when data is not being transmitted. That is, the specification does not include a continuously running clock on the bus cable.
- Because MIL-1553B is a standard, reliable LSI interface circuits are available to handle the protocol.
- The MIL-1553B specification supports "dumb" remote terminals. That means no processor is required in the RT.
- The MIL-1553B Remote Terminals can be located near the data sources which may be up to a few hundred feet from the controller.

5.0 I/O INTERFACE

This section describes the characteristics of the I/O interface.

5.1 Analog Input

The A-D input is designed for high level analog signals within a -10 to +10 volt range. Although the chassis presents a high input impedance to the attached signals, the usual capacitive characteristics of these multiplexed inputs requires the signal source impedance to be 2 kohms or less to preserve the 12-bit accuracy of the system. Each analog connector provides for sixteen differential input signals.

Pins 17,18, and 19 of the analog input connector may be jumpered to +5 volts. This is intended to operate low power temperature sensors such as the National LM-34. Short circuit protection is provided by a 50 ohm resistor in series with the +5 volt supply.

A word of caution: Although the differential input voltage has a range of $\pm 10V$, the sum of the differential and common mode voltages should not exceed $\pm 10V$ on either input. For example, an isolated 1.5V battery attached to an input channel may drift to a common mode voltage near 10V resulting in a incorrect reading of the battery voltage.

5.2 Analog Output

Four analog output signals are available on each of two 9-pin D connectors. These D-A outputs can source 5 ma in the range -10 to +10 volts with a resolution of 12 bits.

5.3 Digital Input/Output

There are four words of digital I/O data accessed by four 37-pin connectors. Data direction of each word is separately selected by a front panel switch piano DIP switch. For a given connector, a switch in the up position corresponds to input. When a port is selected for digital output, data bits are written into "readback" latches so that the output data may be read by the computer. This feature is necessary in order to be able to set or clear individual bits in the output word. The same sub-address is used to write or read a given output word.

The pinout of the digital output connectors was arranged to allow direct connection to OPTO22 I/O modules. Pin 17 of these connectors provides +5 volts to drive the OPTO22 modules. Pin 18 of the output connector is a strobe signal that indicates when data is written to the output port. New data is stable on the trailing edge of the strobe.

When a digital word is selected for input, each bit is internally pulled up to +5V with a 10 kohm resistor so that an isolated external switch contact can be used as an input bit.

Note that, multiple word MIL-1553B commands can be used to read or write several words to a selected digital port. For each new word, a 5-bit counter is incremented to indicate the number of the word being read or written. This counter begins at zero for the first word, and counts up for succeeding words. As shown in the connector pinout diagram, the counter bits 4..0 are connected to pins 37..33 of the digital I/O connectors. The counter may be disabled by setting the front panel counter disable switch to its down position. To read multiple words into a single digital port, the counter bits may be used by the external equipment to multiplex data onto the data lines.

Multiple words may be written to external equipment by using the counter bits to address the registers and storing data in the selected

register on the trailing edge of the positive 1μs strobe pulse.

6.0 OPERATION OF THE MONITOR

The Monitor Module appears to the MIL-1553B controller as a normal MIL-1553B Remote Terminal that makes use of the sub-addresses given in Table 2. The operation of the digitizer requires that the desired starting channel number be sent before the A-D is read out. This allows any selected group of channels to be read from the 64 channels that are available. The starting channel is sent using the "Synchronize Mode Code with Data" command, a command that can be sent to a selected RT address or to all the RTs on a given bus using the broadcast address (\$31).

The A-D immediately digitizes the channel indicated by the Synchronize data. A subsequent multiple word transmit command sent to a specific RT address and subaddress number 20 (\$14), will cause the monitor module to return requested data. Because the maximum word count allowed by the MIL-1553B specification is 32, two transmit commands are required to read all 64 analog channels in a single module. The D-A settings and access to the digital I/O data is accomplished using one word transfers listed in the Table 2.

Subaddress \$1E accesses information from an ID/Status register in the monitor. The upper byte of this word contains an 8-bit identification number that is defined by cut-trace options on the board at the time of manufacture. This byte can be read by the control computer and compared with the expected value, a feature that is particularly useful for a chassis that are part of a large system. Front panel switch information is returned in the low byte of the ID/Status register word; bit 6 is the oscillator switch status (0 = Oscillator ON), bit 5 is the counter status (0 = Counter OFF) and bits 4..1 are the data directions of digital data on connectors P8, P3, P7, and P2, respectively (0 = OUTPUT, 1 = INPUT). For all front panel piano dip switches, 0 = switch in the *down* position, 1 = switch in the *up* position

Subaddress	T/R	Word Count	Description
\$01	0 (1)	1	D-A 0 P4-1 (<i>T/R=1 reads D-A setting</i>)
\$02	0 (1)	1	D-A 1 P4-2
\$03	0 (1)	1	D-A 2 P4-3
\$04	0 (1)	1	D-A 3 P4-4
\$05	0 (1)	1	D-A 4 P9-1
\$06	0 (1)	1	D-A 5 P9-2
\$07	0 (1)	1	D-A 6 P9-3
\$08	0 (1)	1	D-A 7 P9-4
\$09-\$0F	x	x	Not Used
\$10	1 or 0	0-\$1F	Digital I/O P3 (<i>TR=1,input; 0=output</i>)
\$11	1 or 0	0-\$1F	Digital I/O P8
\$12	1 or 0	0-\$1F	Digital I/O P2
\$13	1 or 0	0-\$1F	Digital I/O P7
\$14	1	0-\$1F	Read A-D Data P5, P6, P10, P11
\$15-\$1D	x	x	Not Used
\$1E	1	1	Status/ID word
\$1F	0	\$11	Synchronize Mode Code with Data (Data is Starting A-D Ch. No.)

Note: T/R = 1 for a read operation; T/R = 0 for a write

Table 2. Valid MIL-STD-1553B Commands for the Rack Monitor RT

The module Remote Terminal (RT) address is set by front panel switches. Note that the switch value is only read into the interface chip at **power-on** time or at **reset** time. Therefore, if an RT switch bit is changed while the monitor is in use, the new address will not become active unless the MIL-1553B transmissions are interrupted for about 10 seconds, or the power to the monitor is cycled. Of course, each Rack Monitor on a given bus must have a unique address. Duplicate addresses will cause errors on the bus.

7.0 Oscillator Power

An option was included to allow the oscillators, required to operate the MIL-1553B interface

and the A-D converter, to be powered down during periods of inactivity. In this mode, the oscillator power would turn off a preset time following the last activity on a given 1553 cable. The oscillators turn on slowly, so a dummy transmission would be required to reactivate the oscillators. Switching between the oscillator power modes requires moving one chip on the circuit board. At the present time, the software does not support the pulsed power mode and it is expected that the pulsed mode may not be used. In any case, use of this mode would probably require data acquisition at less than the current 15 Hz rate.



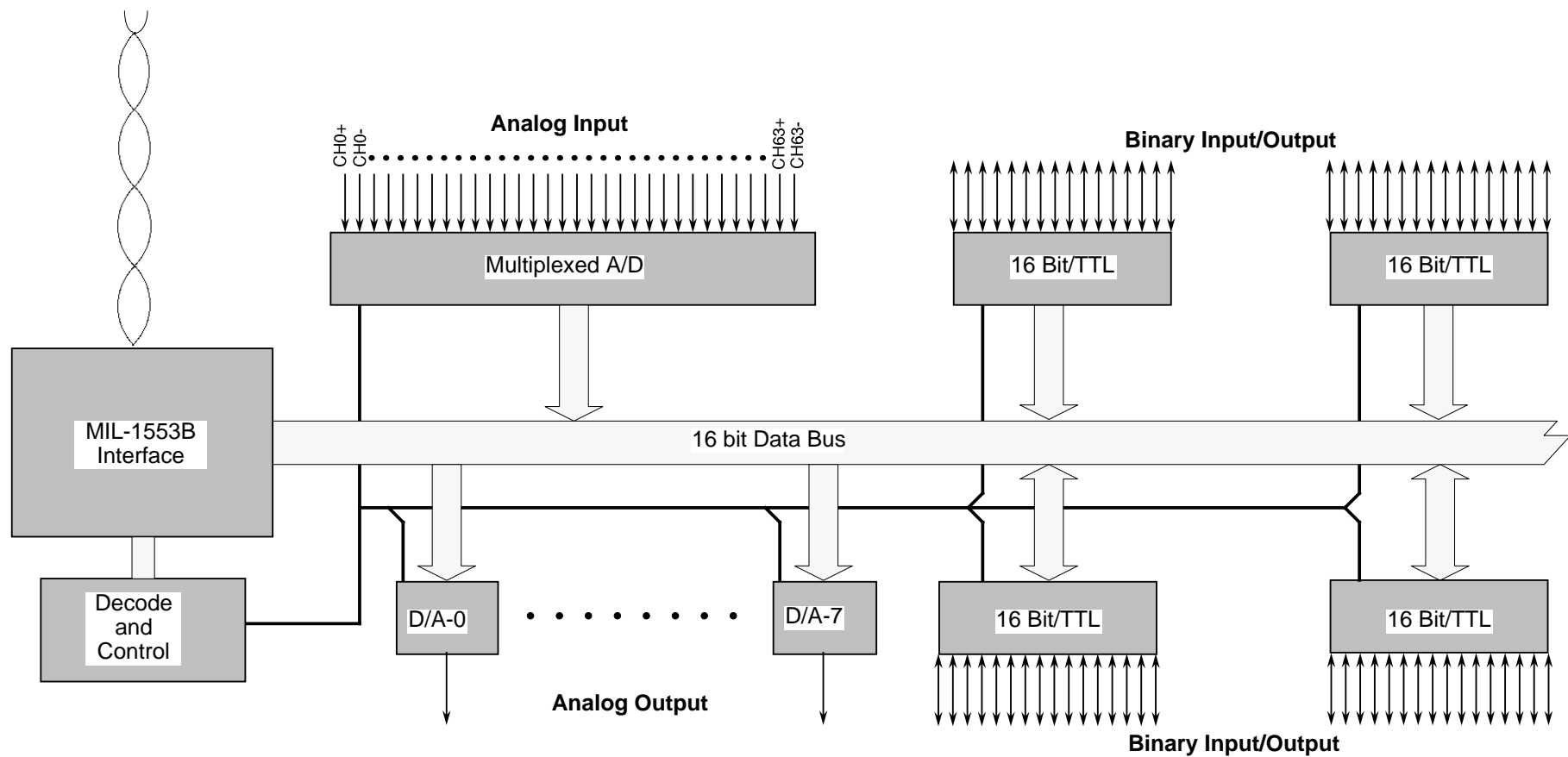


Figure 1. D0 Rack Monitor Block Diagram

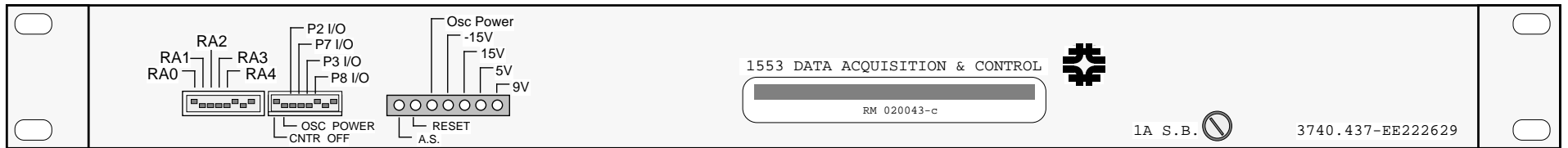


Figure 2a.

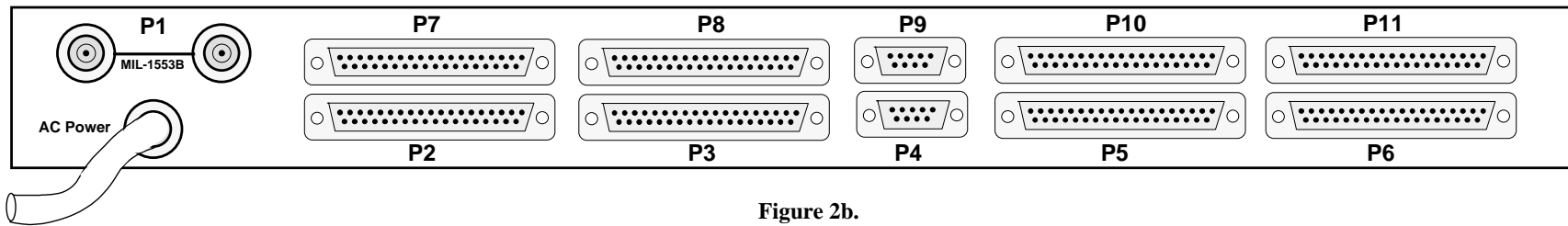


Figure 2b.

Figure 2. Rack Monitor Front and Rear Panel Diagram

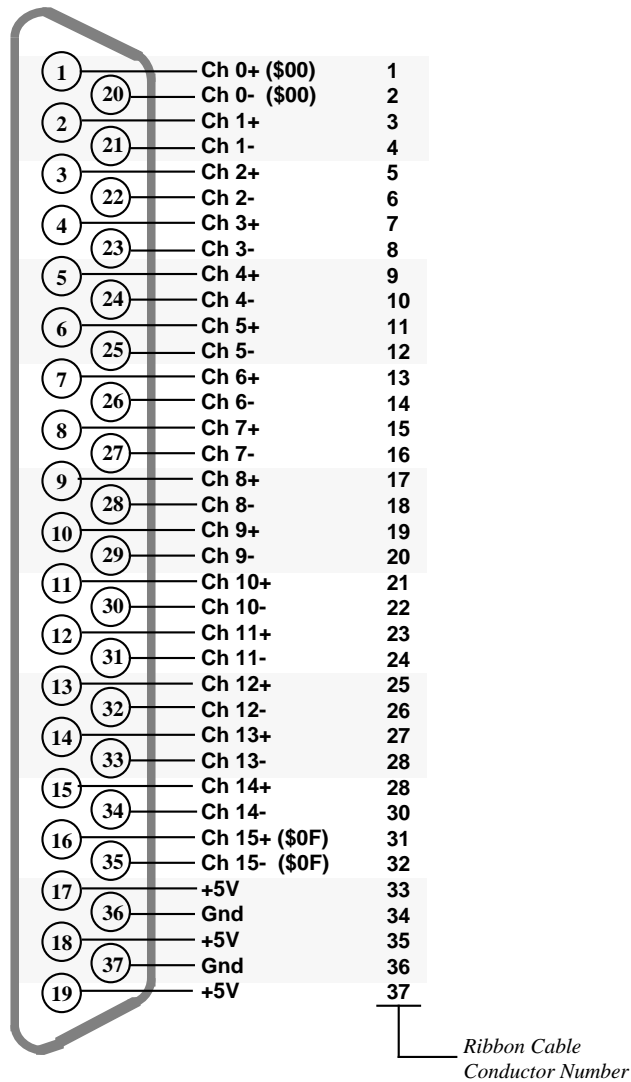


Figure 3a. Analog Input Connector P5
37-Socket "D" Connector Pinout

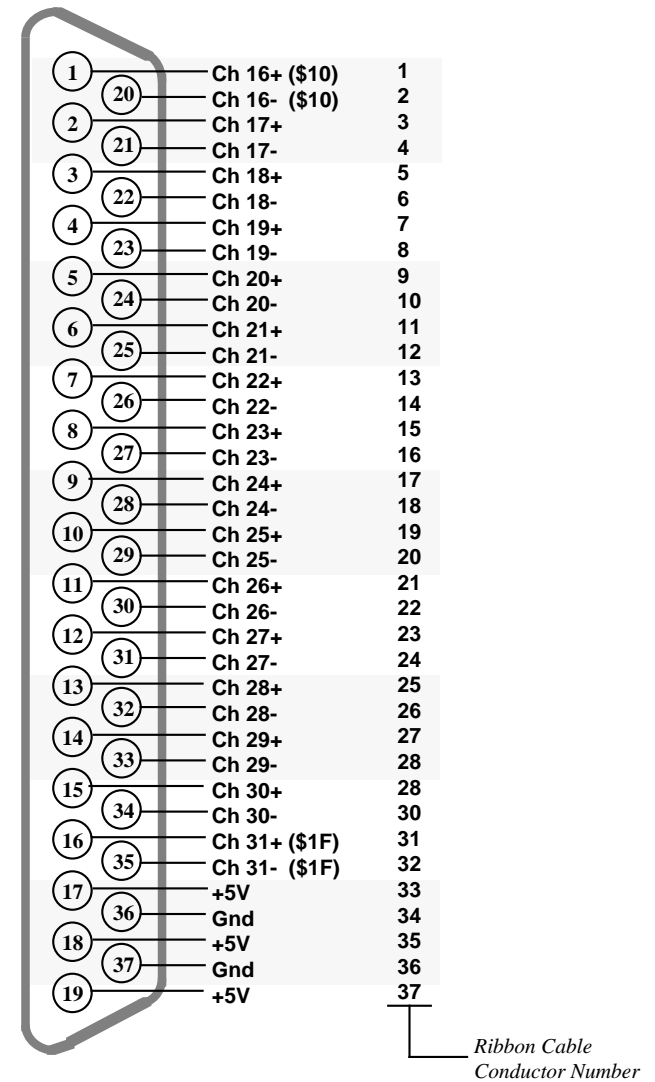
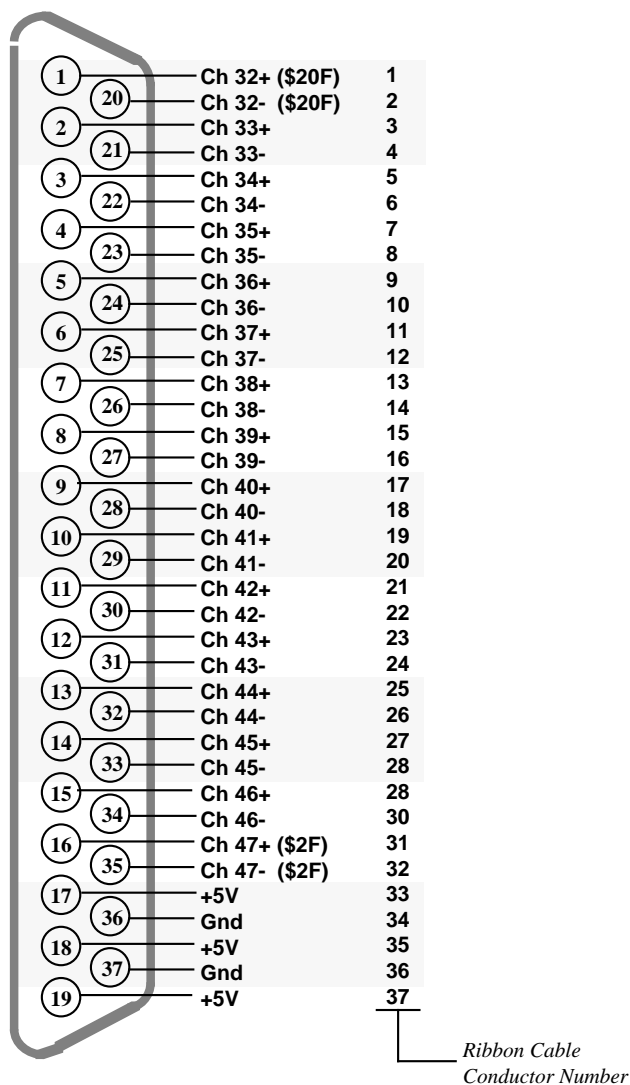
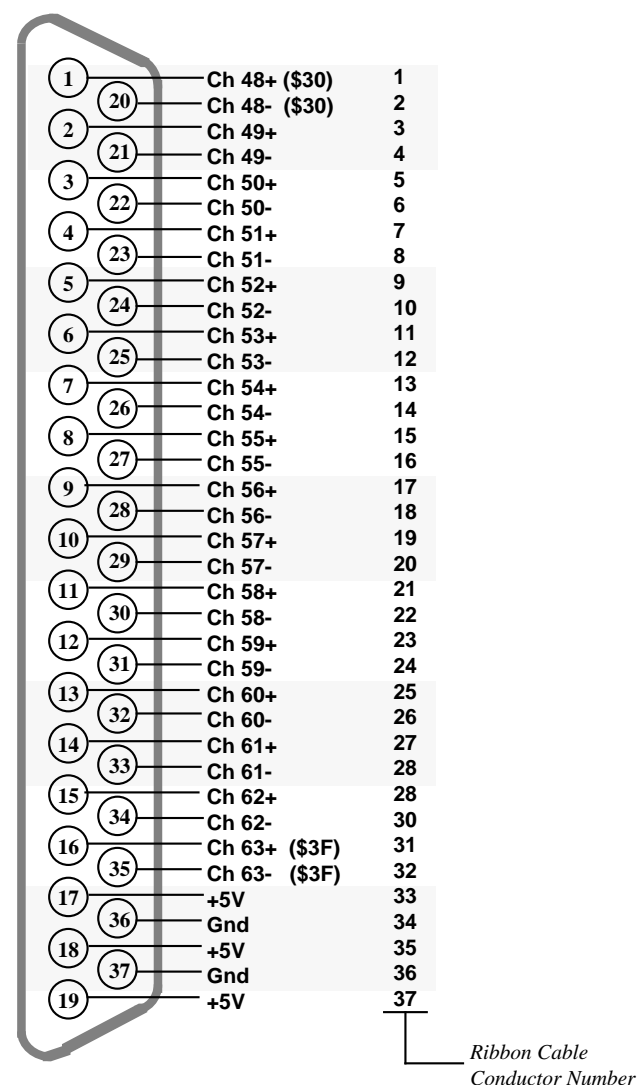


Figure 3b. Analog Input Connector P6
37-Socket "D" Connector Pinout



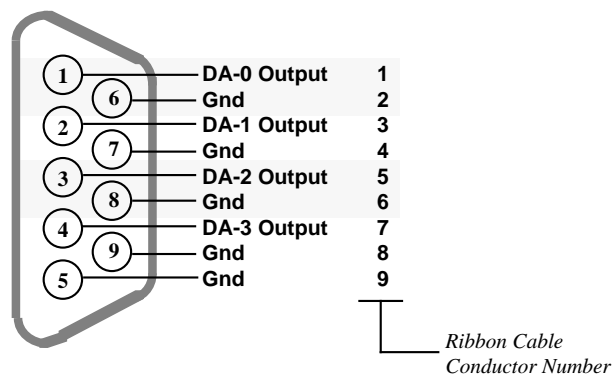
Note: +5V on pins 17, 18, and 19 is optional

Figure 3c. Analog Input Connector P10
37-Socket "D" Connector Pinout

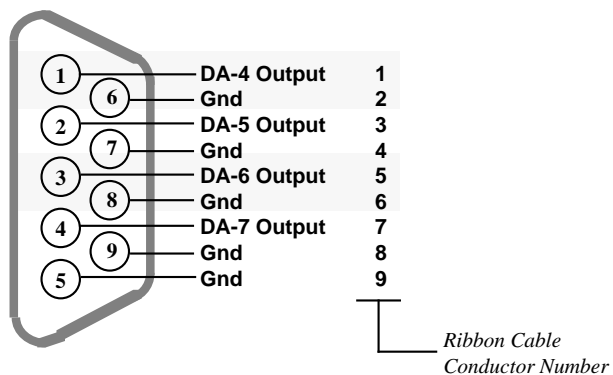


Note: +5V on pins 17, 18, and 19 is optional

Figure 3d. Analog Input Connector P11
37-Socket "D" Connector Pinout

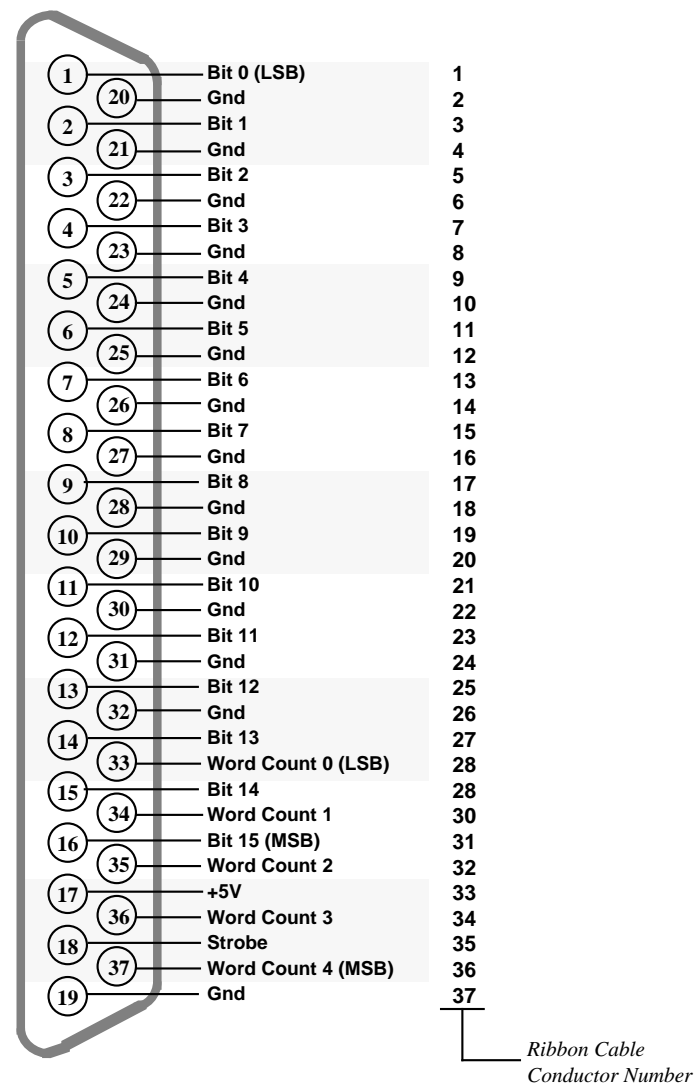


Connector P4



Connector P9

**Figure 3e. Analog Output Connector
9-Socket "D" Connector Pinout**



Note: Data Direction of each digital I/O word may be selected separately

**Figure 3f. DZero Rack Monitor P2, P3, P7 and P8
Digital Connector Pinout**